Final Report of Scientific Results

A ROSAT Study of X-Ray Flickering on II Pegasi and Observations of Flares in II Peg Through Time Series Spectroscopy

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Introduction:

The contact was to conduct a study the X-ray properties of The RS Canum Venaticorum system II Pegasi. Specifically addressed were the X-ray spectral properties as well as the nature of the flaring induced transient changes in the X-ray spectra.

The active star II Pegasi is a 6.7 day period single lined spectroscopic binary. It is very active having a highly variable visible light curve, strong Balmer and CaII emission in the visible spectrum, a high X-ray luminosity. Strassmeier et al. (1993) present the fundamental data and the references to it. Flares have been reported previously in this system (Mathioudakis et al. 1992; Doyle et al. 1991; Tagliaferri et al. 1991; Huenemoerder et al. 1990; Hunemoerder & Ramsey, 1987).

The primary goal of the ROSAT observations were to watch for flares and determine the change they might have on the X-ray spectral characteristics. II Pegasi has a large X-ray flux with about 5 counts/sec in the ROSAT PSPC. This allows good statistics on the integrated flux over the entire PSPC bandpass in a few minutes. In addition, our long term optical observation of Balmer line indicates that II Peg undergoes small to medium flare events frequently. The direct evidence for this is the 20% modulation of Hα flux. This alone is not sufficient to characterize flaring. Our echelle data obtains higher Balmer lines simultaneously and we utilize a decrease of the Hα/Hβ ratios as a flare indicators. This is derived from solar observations. From the fluctuations in the Hα/Hβ ratios, we estimated that three to four hours of ROSAT observations would give us a very high probability of observing a flare event. Observing such an event would enable us to compare the X-ray spectrum in and out of the x-ray flare. This would give us unprecedented opportunity to compare the flares in other stars with those observed on the sun. Both the spectral character and the amplitude fluctuations bear information on the nature of the X-ray activity and would potential allow further insight into what the optical data is telling us.

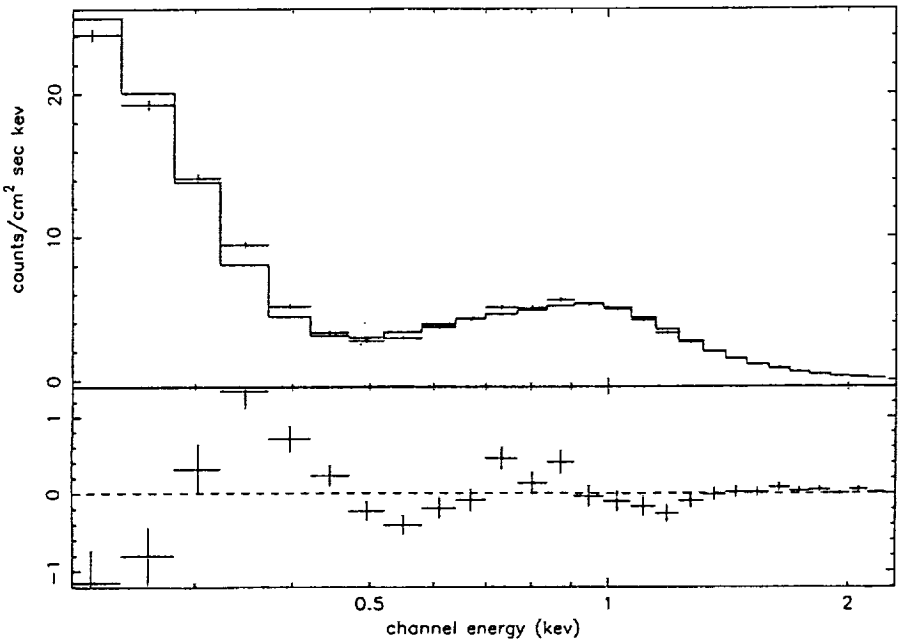

Figure 1: X-ray spectrum of II Peg (points) with a two temperature component model with no neutral hydrogen absorption (solid line). Bottom half of the frame is the residual.

X-Ray observations

II Peg was observed with ROSAT during the survey (Dempsy et al. 1993) and with 3600seconds,over about 2 hours and 20 minutes, of pointed PSPC observations during the summer of 1991. The proposed of the pointed observations were for 10,000 seconds however spacecraft problems during that period precluded that goal from being reached. The 3,600 seconds obtained was enough to get a very good spectrum but totally inadequate for detailed timing analysis which was the major thrust of our proposed science. Thus the timing aspect of the proposed project ca only be characterized as a failure. While some apparently significant fluctuations are in the data, these cannot unambiguously be ascribed to the star due to occultation with the filter support.

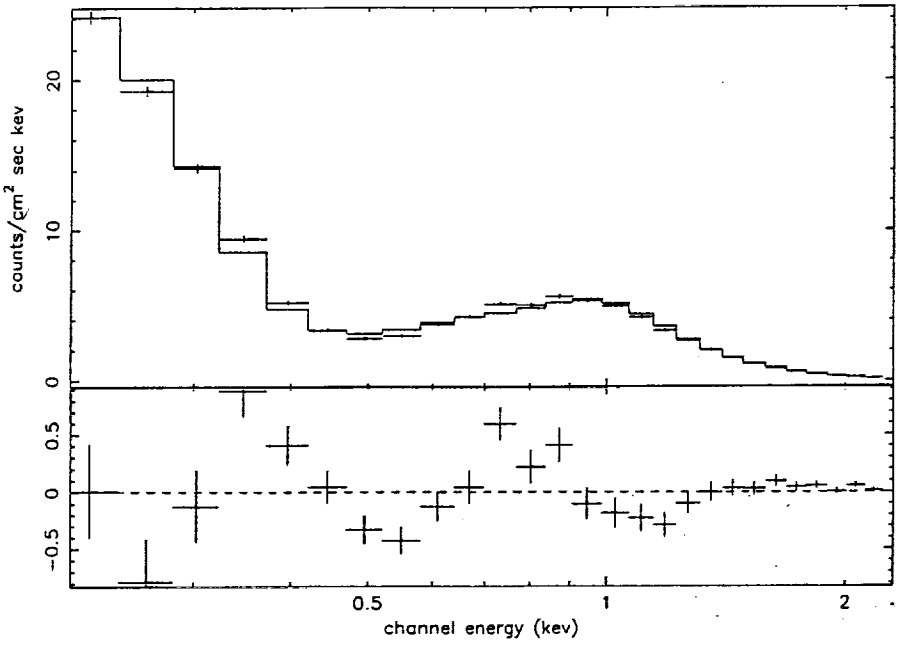

Figure 2: Same data as in Figure 1 but with a two temperature component model with a column density of 2.8×10^{19} neutral hydrogen absorption (solid line).

The PSPC data we did obtain was analyzed for the character of the spectrum and comparison to public data from the all sky survey. This analysis required a multi-component fit. Figure 1 presnts the data and a basi two temperature component fit to this data with no neutral hydrogen absorption. An improved fit is obtained by allowing the neutral hydrogen absorption to also vary. These results are presented in Figure 2. Parameters of a two component fit that was adopted were as follows:

T1= 2,000,000 °K
T2= 18,000,000 °K
EM1=1.2×10^{53} cm-3
EM2= 3.6×10^{53} cm-3
NH = 2.8×10^{19} cm-2.

The substantially y lower residuals are readily apparent in Figure 2. In both Figure 1 and Figure 2, the spectrum is display folded with the system response. Figure 3, on the other hand, displays the astrophysical spectral; tie with the system response removed.

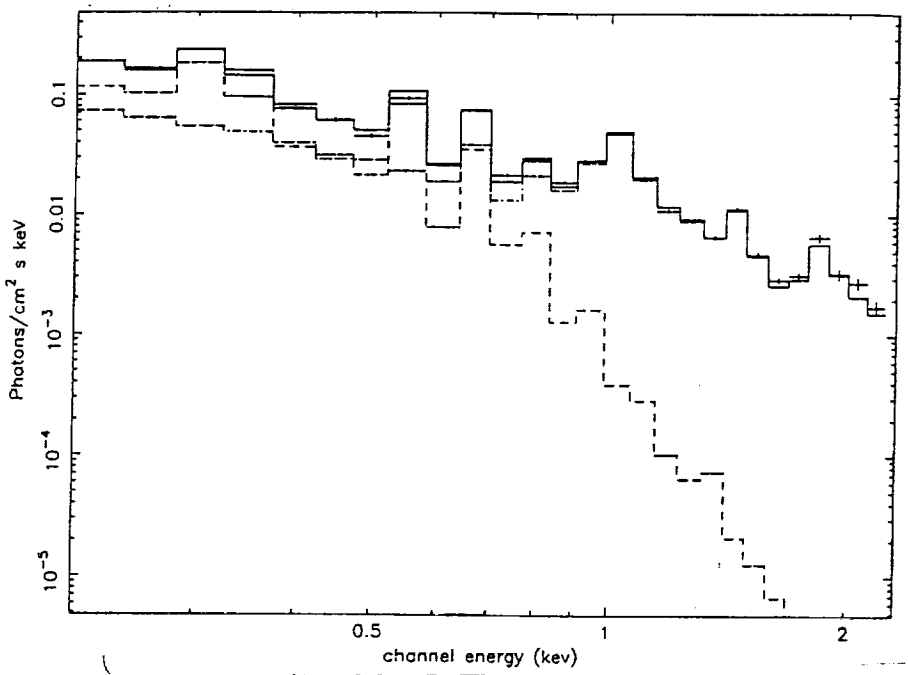

Figure 3: Same data and model as in Figure 2 but with the system response unfolded.

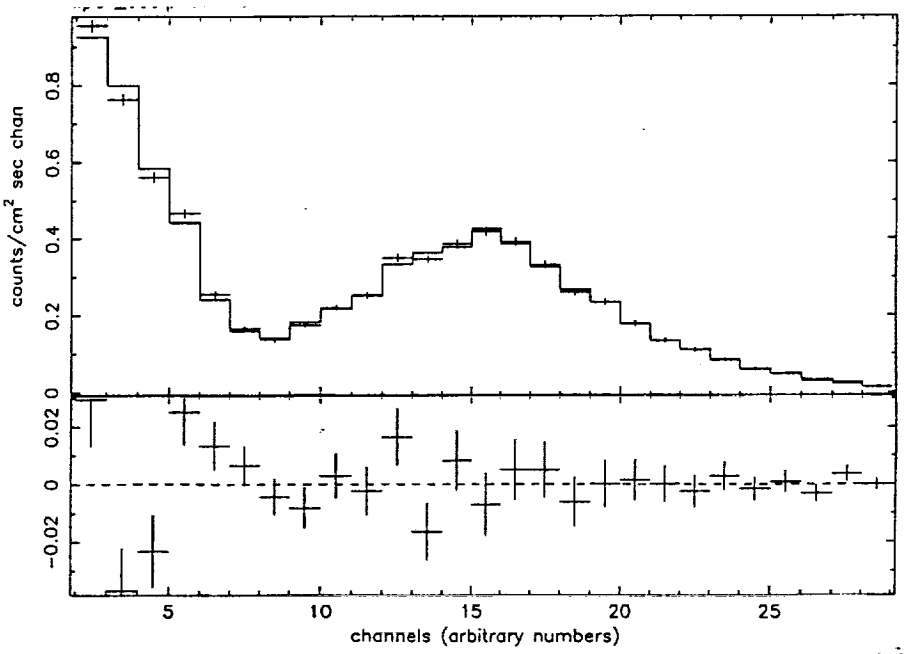

Figure 4: Same data as in Figure 1 but with a three temperature component model with a column density of 2.8×10^{19} neutral hydrogen absorption (solid line).

The reduced chi squared was 4.7 and the rms. residuals were 10%. The flux luminosity (0.1-2.5 keV) were fx= 7.2 x 10^{-11} erg/cm-2s-1 and Lx=7.5 x 10^{30} erg s-1. Dempsy et al (1993) derived and emission measure ratio of 1:18 for a two temperature fit to the survey data with similar temperatures as we derived above from our pointed data. The data quality do not allow us to unambiguously state if this is due to variability or not. A three temperature fit is slightly better. The difference in the high temperature component occurred near 1 keV were there are many metal emission lines unresolved in the PSPC spectrum. The results of this model are in Figure 3. This suggests that there is a physical reason for he lower X2 and that II Peg's emission is better described by a continuous emission measure distribution. The residuals were equally bad in both two and three temperature fits over the detector edge near 0.3 keV)

References

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Papers published

The X-ray results were publised as part of anotehr paper in
Huenemoerder,D.P. *Cool Stars, Stellars Systems and the Sun*, ASP Vol **64**, eds Jean Pierre Caillault, 1994, p708.